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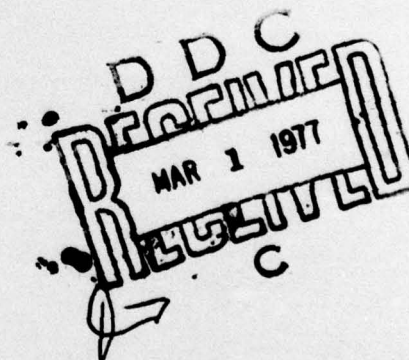
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# RESEARCH ON PERMEABILITY OF CERTAIN KINDS OF WEAK WATER-SATURATED SOILS

B. Kirov



CORPS OF ENGINEERS, U.S. ARMY  
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY  
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REPORT TO THE DIRECTOR	
1. TITLE AND SYNOPSIS	
2. SUMMARY OF FACTS	
3. ANALYSIS OF FACTS	
4. CONCLUSIONS	
5. RECOMMENDATIONS	
6. REFERENCES	
7. DISTRIBUTION STATEMENT	
8. SUPPLEMENTARY NOTES	
9. ABSTRACT	
10. INDEXING	
11. CHARACTERISTICS	
12. COMMENTS	
13. APPROVAL FOR PUBLICATION	
14. DISTRIBUTION STATEMENT	
15. SUPPLEMENTARY NOTES	
16. ABSTRACT	
17. INDEXING	
18. CHARACTERISTICS	
19. COMMENTS	
20. APPROVAL FOR PUBLICATION	
21. DISTRIBUTION STATEMENT	
22. SUPPLEMENTARY NOTES	
23. ABSTRACT	
24. INDEXING	
25. CHARACTERISTICS	
26. COMMENTS	
27. APPROVAL FOR PUBLICATION	
28. DISTRIBUTION STATEMENT	
29. SUPPLEMENTARY NOTES	
30. ABSTRACT	
31. INDEXING	
32. CHARACTERISTICS	
33. COMMENTS	
34. APPROVAL FOR PUBLICATION	
35. DISTRIBUTION STATEMENT	
36. SUPPLEMENTARY NOTES	
37. ABSTRACT	
38. INDEXING	
39. CHARACTERISTICS	
40. COMMENTS	
41. APPROVAL FOR PUBLICATION	
42. DISTRIBUTION STATEMENT	
43. SUPPLEMENTARY NOTES	
44. ABSTRACT	
45. INDEXING	
46. CHARACTERISTICS	
47. COMMENTS	
48. APPROVAL FOR PUBLICATION	
49. DISTRIBUTION STATEMENT	
50. SUPPLEMENTARY NOTES	
51. ABSTRACT	
52. INDEXING	
53. CHARACTERISTICS	
54. COMMENTS	
55. APPROVAL FOR PUBLICATION	
56. DISTRIBUTION STATEMENT	
57. SUPPLEMENTARY NOTES	
58. ABSTRACT	
59. INDEXING	
60. CHARACTERISTICS	
61. COMMENTS	
62. APPROVAL FOR PUBLICATION	
63. DISTRIBUTION STATEMENT	
64. SUPPLEMENTARY NOTES	
65. ABSTRACT	
66. INDEXING	
67. CHARACTERISTICS	
68. COMMENTS	
69. APPROVAL FOR PUBLICATION	
70. DISTRIBUTION STATEMENT	
71. SUPPLEMENTARY NOTES	
72. ABSTRACT	
73. INDEXING	
74. CHARACTERISTICS	
75. COMMENTS	
76. APPROVAL FOR PUBLICATION	
77. DISTRIBUTION STATEMENT	
78. SUPPLEMENTARY NOTES	
79. ABSTRACT	
80. INDEXING	
81. CHARACTERISTICS	
82. COMMENTS	
83. APPROVAL FOR PUBLICATION	
84. DISTRIBUTION STATEMENT	
85. SUPPLEMENTARY NOTES	
86. ABSTRACT	
87. INDEXING	
88. CHARACTERISTICS	
89. COMMENTS	
90. APPROVAL FOR PUBLICATION	
91. DISTRIBUTION STATEMENT	
92. SUPPLEMENTARY NOTES	
93. ABSTRACT	
94. INDEXING	
95. CHARACTERISTICS	
96. COMMENTS	
97. APPROVAL FOR PUBLICATION	
98. DISTRIBUTION STATEMENT	
99. SUPPLEMENTARY NOTES	
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101. INDEXING	
102. CHARACTERISTICS	
103. COMMENTS	
104. APPROVAL FOR PUBLICATION	
105. DISTRIBUTION STATEMENT	
106. SUPPLEMENTARY NOTES	
107. ABSTRACT	
108. INDEXING	
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110. COMMENTS	
111. APPROVAL FOR PUBLICATION	
112. DISTRIBUTION STATEMENT	
113. SUPPLEMENTARY NOTES	
114. ABSTRACT	
115. INDEXING	
116. CHARACTERISTICS	
117. COMMENTS	
118. APPROVAL FOR PUBLICATION	
119. DISTRIBUTION STATEMENT	
120. SUPPLEMENTARY NOTES	
121. ABSTRACT	
122. INDEXING	
123. CHARACTERISTICS	
124. COMMENTS	
125. APPROVAL FOR PUBLICATION	
126. DISTRIBUTION STATEMENT	
127. SUPPLEMENTARY NOTES	
128. ABSTRACT	
129. INDEXING	
130. CHARACTERISTICS	
131. COMMENTS	
132. APPROVAL FOR PUBLICATION	
133. DISTRIBUTION STATEMENT	
134. SUPPLEMENTARY NOTES	
135. ABSTRACT	
136. INDEXING	
137. CHARACTERISTICS	
138. COMMENTS	
139. APPROVAL FOR PUBLICATION	
140. DISTRIBUTION STATEMENT	
141. SUPPLEMENTARY NOTES	
142. ABSTRACT	
143. INDEXING	
144. CHARACTERISTICS	
145. COMMENTS	
146. APPROVAL FOR PUBLICATION	
147. DISTRIBUTION STATEMENT	
148. SUPPLEMENTARY NOTES	
149. ABSTRACT	
150. INDEXING	
151. CHARACTERISTICS	
152. COMMENTS	
153. APPROVAL FOR PUBLICATION	
154. DISTRIBUTION STATEMENT	
155. SUPPLEMENTARY NOTES	
156. ABSTRACT	
157. INDEXING	
158. CHARACTERISTICS	
159. COMMENTS	
160. APPROVAL FOR PUBLICATION	
161. DISTRIBUTION STATEMENT	
162. SUPPLEMENTARY NOTES	
163. ABSTRACT	
164. INDEXING	
165. CHARACTERISTICS	
166. COMMENTS	
167. APPROVAL FOR PUBLICATION	
168. DISTRIBUTION STATEMENT	
169. SUPPLEMENTARY NOTES	
170. ABSTRACT	
171. INDEXING	
172. CHARACTERISTICS	
173. COMMENTS	
174. APPROVAL FOR PUBLICATION	
175. DISTRIBUTION STATEMENT	
176. SUPPLEMENTARY NOTES	
177. ABSTRACT	
178. INDEXING	
179. CHARACTERISTICS	
180. COMMENTS	
181. APPROVAL FOR PUBLICATION	
182. DISTRIBUTION STATEMENT	
183. SUPPLEMENTARY NOTES	
184. ABSTRACT	
185. INDEXING	
186. CHARACTERISTICS	
187. COMMENTS	
188. APPROVAL FOR PUBLICATION	
189. DISTRIBUTION STATEMENT	
190. SUPPLEMENTARY NOTES	
191. ABSTRACT	
192. INDEXING	
193. CHARACTERISTICS	
194. COMMENTS	
195. APPROVAL FOR PUBLICATION	
196. DISTRIBUTION STATEMENT	
197. SUPPLEMENTARY NOTES	
198. ABSTRACT	
199. INDEXING	
200. CHARACTERISTICS	
201. COMMENTS	
202. APPROVAL FOR PUBLICATION	
203. DISTRIBUTION STATEMENT	
204. SUPPLEMENTARY NOTES	
205. ABSTRACT	
206. INDEXING	
207. CHARACTERISTICS	
208. COMMENTS	
209. APPROVAL FOR PUBLICATION	
210. DISTRIBUTION STATEMENT	
211. SUPPLEMENTARY NOTES	
212. ABSTRACT	
213. INDEXING	
214. CHARACTERISTICS	
215. COMMENTS	
216. APPROVAL FOR PUBLICATION	
217. DISTRIBUTION STATEMENT	
218. SUPPLEMENTARY NOTES	
219. ABSTRACT	
220. INDEXING	
221. CHARACTERISTICS	
222. COMMENTS	
223. APPROVAL FOR PUBLICATION	
224. DISTRIBUTION STATEMENT	
225. SUPPLEMENTARY NOTES	
226. ABSTRACT	
227. INDEXING	
228. CHARACTERISTICS	
229. COMMENTS	
230. APPROVAL FOR PUBLICATION	
231. DISTRIBUTION STATEMENT	
232. SUPPLEMENTARY NOTES	
233. ABSTRACT	
234. INDEXING	
235. CHARACTERISTICS	
236. COMMENTS	
237. APPROVAL FOR PUBLICATION	
238. DISTRIBUTION STATEMENT	
239. SUPPLEMENTARY NOTES	
240. ABSTRACT	
241. INDEXING	
242. CHARACTERISTICS	
243. COMMENTS	
244. APPROVAL FOR PUBLICATION	
245. DISTRIBUTION STATEMENT	
246. SUPPLEMENTARY NOTES	
247. ABSTRACT	
248. INDEXING	
249. CHARACTERISTICS	
250. COMMENTS	
251. APPROVAL FOR PUBLICATION	
252. DISTRIBUTION STATEMENT	
253. SUPPLEMENTARY NOTES	
254. ABSTRACT	
255. INDEXING	
256. CHARACTERISTICS	
257. COMMENTS	
258. APPROVAL FOR PUBLICATION	
259. DISTRIBUTION STATEMENT	
260. SUPPLEMENTARY NOTES	
261. ABSTRACT	
262. INDEXING	
263. CHARACTERISTICS	
264. COMMENTS	
265. APPROVAL FOR PUBLICATION	
266. DISTRIBUTION STATEMENT	
267. SUPPLEMENTARY NOTES	
268. ABSTRACT	
269. INDEXING	
270. CHARACTERISTICS	
271. COMMENTS	
272. APPROVAL FOR PUBLICATION	
273. DISTRIBUTION STATEMENT	
274. SUPPLEMENTARY NOTES	
275. ABSTRACT	
276. INDEXING	
277. CHARACTERISTICS	
278. COMMENTS	
279. APPROVAL FOR PUBLICATION	
280. DISTRIBUTION STATEMENT	
281. SUPPLEMENTARY NOTES	
282. ABSTRACT	
283. INDEXING	
284. CHARACTERISTICS	
285. COMMENTS	
286. APPROVAL FOR PUBLICATION	
287. DISTRIBUTION STATEMENT	
288. SUPPLEMENTARY NOTES	
289. ABSTRACT	
290. INDEXING	
291. CHARACTERISTICS	
292. COMMENTS	
293. APPROVAL FOR PUBLICATION	
294. DISTRIBUTION STATEMENT	
295. SUPPLEMENTARY NOTES	
296. ABSTRACT	
297. INDEXING	
298. CHARACTERISTICS	
299. COMMENTS	
300. APPROVAL FOR PUBLICATION	
301. DISTRIBUTION STATEMENT	
302. SUPPLEMENTARY NOTES	
303. ABSTRACT	
304. INDEXING	
305. CHARACTERISTICS	
306. COMMENTS	
307. APPROVAL FOR PUBLICATION	
308. DISTRIBUTION STATEMENT	
309. SUPPLEMENTARY NOTES	
310. ABSTRACT	
311. INDEXING	
312. CHARACTERISTICS	
313. COMMENTS	
314. APPROVAL FOR PUBLICATION	
315. DISTRIBUTION STATEMENT	
316. SUPPLEMENTARY NOTES	
317. ABSTRACT	
318. INDEXING	
319. CHARACTERISTICS	
320. COMMENTS	
321. APPROVAL FOR PUBLICATION	
322. DISTRIBUTION STATEMENT	
323. SUPPLEMENTARY NOTES	
324. ABSTRACT	
325. INDEXING	
326. CHARACTERISTICS	
327. COMMENTS	
328. APPROVAL FOR PUBLICATION	
329. DISTRIBUTION STATEMENT	
330. SUPPLEMENTARY NOTES	
331. ABSTRACT	
332. INDEXING	
333. CHARACTERISTICS	
334. COMMENTS	
335. APPROVAL FOR PUBLICATION	
336. DISTRIBUTION STATEMENT	
337. SUPPLEMENTARY NOTES	
338. ABSTRACT	
339. INDEXING	
340. CHARACTERISTICS	
341. COMMENTS	
342. APPROVAL FOR PUBLICATION	
343. DISTRIBUTION STATEMENT	
344. SUPPLEMENTARY NOTES	
345. ABSTRACT	
346. INDEXING	
347. CHARACTERISTICS	
348. COMMENTS	
349. APPROVAL FOR PUBLICATION	
350. DISTRIBUTION STATEMENT	
351. SUPPLEMENTARY NOTES	
352. ABSTRACT	
353. INDEXING	
354. CHARACTERISTICS	
355. COMMENTS	
356. APPROVAL FOR PUBLICATION	
357. DISTRIBUTION STATEMENT	
358. SUPPLEMENTARY NOTES	
359. ABSTRACT	
360. INDEXING	
361. CHARACTERISTICS	
362. COMMENTS	
363. APPROVAL FOR PUBLICATION	
364. DISTRIBUTION STATEMENT	
365. SUPPLEMENTARY NOTES	
366. ABSTRACT	
367. INDEXING	
368. CHARACTERISTICS	
369. COMMENTS	
370. APPROVAL FOR PUBLICATION	
371. DISTRIBUTION STATEMENT	
372. SUPPLEMENTARY NOTES	
373. ABSTRACT	
374. INDEXING	
375. CHARACTERISTICS	
376. COMMENTS	
377. APPROVAL FOR PUBLICATION	
378. DISTRIBUTION STATEMENT	
379. SUPPLEMENTARY NOTES	
380. ABSTRACT	
381. INDEXING	
382. CHARACTERISTICS	
383. COMMENTS	
384. APPROVAL FOR PUBLICATION	
385. DISTRIBUTION STATEMENT	
386. SUPPLEMENTARY NOTES	
387. ABSTRACT	
388. INDEXING	
389. CHARACTERISTICS	
390. COMMENTS	
391. APPROVAL FOR PUBLICATION	
392. DISTRIBUTION STATEMENT	
393. SUPPLEMENTARY NOTES	
394. ABSTRACT	
395. INDEXING	
396. CHARACTERISTICS	
397. COMMENTS	
398. APPROVAL FOR PUBLICATION	
399. DISTRIBUTION STATEMENT	
400. SUPPLEMENTARY NOTES	
401. ABSTRACT	
402. INDEXING	
403. CHARACTERISTICS	
404. COMMENTS	
405. APPROVAL FOR PUBLICATION	
406. DISTRIBUTION STATEMENT	
407. SUPPLEMENTARY NOTES	
408. ABSTRACT	
409. INDEXING	
410. CHARACTERISTICS	
411. COMMENTS	
412. APPROVAL FOR PUBLICATION	
413. DISTRIBUTION STATEMENT	
414. SUPPLEMENTARY NOTES	
415. ABSTRACT	
416. INDEXING	
417. CHARACTERISTICS	
418. COMMENTS	
419. APPROVAL FOR PUBLICATION	
420. DISTRIBUTION STATEMENT	
421. SUPPLEMENTARY NOTES	
422. ABSTRACT	
423. INDEXING	
424. CHARACTERISTICS	
425. COMMENTS	
426. APPROVAL FOR PUBLICATION	
427. DISTRIBUTION STATEMENT	
428. SUPPLEMENTARY NOTES	
429. ABSTRACT	
430. INDEXING	
431. CHARACTERISTICS	
432. COMMENTS	
433. APPROVAL FOR PUBLICATION	
434. DISTRIBUTION STATEMENT	
435. SUPPLEMENTARY NOTES	
436. ABSTRACT	
437. INDEXING	
438. CHARACTERISTICS	
439. COMMENTS	
440. APPROVAL FOR PUBLICATION	
441. DISTRIBUTION STATEMENT	
442. SUPPLEMENTARY NOTES	
443. ABSTRACT	
444. INDEXING	
445. CHARACTERISTICS	
446. COMMENTS	
447. APPROVAL FOR PUBLICATION	
448. DISTRIBUTION STATEMENT	
449. SUPPLEMENTARY NOTES	
450. ABSTRACT	
451. INDEXING	
452. CHARACTERISTICS	
453. COMMENTS	
454. APPROVAL FOR PUBLICATION	
455. DISTRIBUTION STATEMENT	
456. SUPPLEMENTARY NOTES	
457. ABSTRACT	
458. INDEXING	
459. CHARACTERISTICS	
460. COMMENTS	
461. APPROVAL FOR PUBLICATION	
462. DISTRIBUTION STATEMENT	
463. SUPPLEMENTARY NOTES	
464. ABSTRACT	
465. INDEXING	
466. CHARACTERISTICS	
467. COMMENTS	
468. APPROVAL FOR PUBLICATION	
469. DISTRIBUTION STATEMENT	
470. SUPPLEMENTARY NOTES	
471. ABSTRACT	
472. INDEXING	
473. CHARACTERISTICS	
474. COMMENTS	
475. APPROVAL FOR PUBLICATION	
476. DISTRIBUTION STATEMENT	
477. SUPPLEMENTARY NOTES	
478. ABSTRACT	
479. INDEXING	
480. CHARACTERISTICS	
481. COMMENTS	
482. APPROVAL FOR PUBLICATION	
483. DISTRIBUTION STATEMENT	
484. SUPPLEMENTARY NOTES	
485. ABSTRACT	
486. INDEXING	
487. CHARACTERISTICS	
488. COMMENTS	
489. APPROVAL FOR PUBLICATION	
490. DISTRIBUTION STATEMENT	
491. SUPPLEMENTARY NOTES	
492. ABSTRACT	
493. INDEXING	
494. CHARACTERISTICS	
495. COMMENTS	
496. APPROVAL FOR PUBLICATION	
497. DISTRIBUTION STATEMENT	
498. SUPPLEMENTARY NOTES	
499. ABSTRACT	
500. INDEXING	
501. CHARACTERISTICS	
502. COMMENTS	
503. APPROVAL FOR PUBLICATION	
504. DISTRIBUTION STATEMENT	
505. SUPPLEMENTARY NOTES	
506. ABSTRACT	
507. INDEXING	
508. CHARACTERISTICS	
509. COMMENTS	
510. APPROVAL FOR PUBLICATION	
511. DISTRIBUTION STATEMENT	
512. SUPPLEMENTARY NOTES	
513. ABSTRACT	
514. INDEXING	
515. CHARACTERISTICS	
516. COMMENTS	
517. APPROVAL FOR PUBLICATION	
518. DISTRIBUTION STATEMENT	
519. SUPPLEMENTARY NOTES	
520. ABSTRACT	
521. INDEXING	
522. CHARACTERISTICS	
523. COMMENTS	
524. APPROVAL FOR PUBLICATION	
525. DISTRIBUTION STATEMENT	
526. SUPPLEMENTARY NOTES	
527. ABSTRACT	
528. INDEXING	
529. CHARACTERISTICS	
530. COMMENTS	
531. APPROVAL FOR PUBLICATION	
532. DISTRIBUTION STATEMENT	
533. SUPPLEMENTARY NOTES	
534. ABSTRACT	
535. INDEXING	
536. CHARACTERISTICS	
537. COMMENTS	
538. APPROVAL FOR PUBLICATION	
539. DISTRIBUTION	

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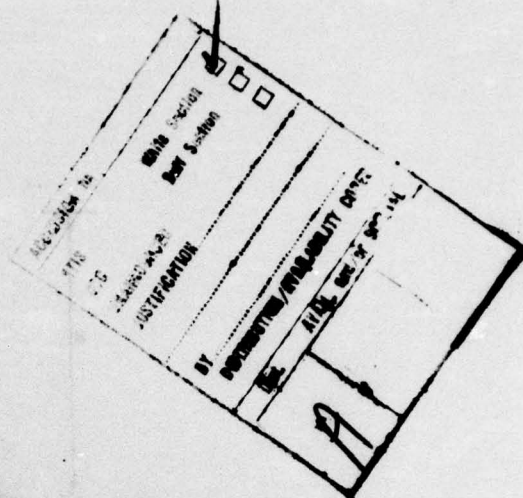
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# RESEARCH ON PERMEABILITY OF CERTAIN KINDS OF WEAK WATER-SATURATED SOILS

by Engineer Borislav Kirov

Гидротехника (Hydraulic Engineering),  
Vol. 19, No. 9, 1974, pp. 25-27

Permeability is an exceptionally important soil characteristic for the planning of engineering structures. It must be determined precisely in order to calculate the consolidation of the earth mass.

The Weak-Soil "Problem" Research Laboratory headed by Docent Candidate of Technical Sciences M. Yu. Abelev in the Soil Mechanics and Foundations Department of the V. V. Kuybyshev Moscow Civil Engineering Institute performed a series of filtration experiments with undestroyed samples of the following varieties of soil: sandy mud, clayey mud and buried peat. Previously vacuum-evaporated sea water was used for filtration. The purpose of the research was to determine the variation of permeability as a function of the degree of soil compaction and pressure gradient. The experiments were performed with the help of an F-1M filtration compressor (Figure 1). It is a compressor with a hermetically sealed holder permitting the passage of water through a soil specimen according to "top-to-bottom" and "bottom-to-top" flow patterns under varying pressure. The installed soil specimen is 0.04 meter high and has a cross-section  $F=50 \cdot 10^{-4}$  square meter.

Three undestroyed samples of each variety were tested. The characteristics of the various soils in the natural state are given in Table 1.

The first task we set ourselves in conducting the experiments was to determine whether the so-called phenomenon of "initial pressure gradient" is observed during filtration through these varieties of weak water-saturated soils, i.e., whether there is some certain pressure gradient value, although there are smaller values, from which no filtration is observed, or if it is observed, it will be many times weaker [1].

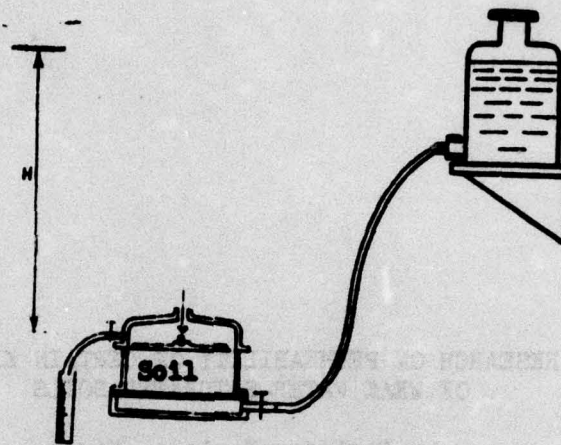


Figure 1

Table 1

1 Вид почвы	5 Объемная плотность $\rho$ [г/см <sup>3</sup> ]	6 Специфическая плотность $\rho_s$ [г/см <sup>3</sup> ]	7 Водное содержание $\omega$ [%]	8 Коэффициент пористости $e$
2 Песчаная глина	1.42	2.65	118	3.06
3 Глинистая глина	1.40	2.63	83	2.44
4 Покрытый торф	1.01	1.95	430	9.23

## Key:

1. Soil type
2. Sandy mud
3. Clayey mud
4. Buried peat
5. Bulk density
6. Specific density
7. Water content
8. Porosity factor



Darcy's equation then assumes the following form:

$$V_f = K_f(1 - i_0),$$

where  $V_f$  is filtration rate,

$i$  is pressure gradient, and

$i_0$  is initial pressure gradient.

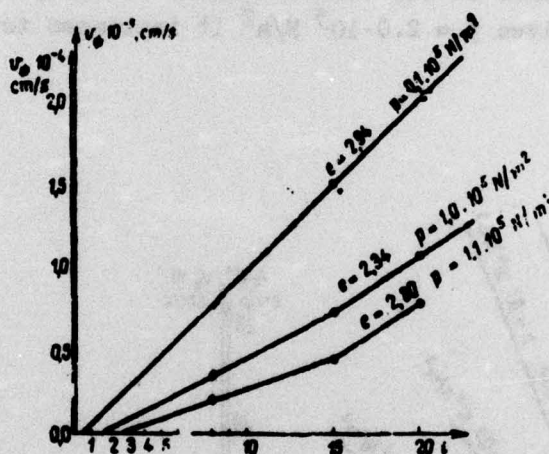


Figure 2a. Sandy mud

The instrument used is so constructed as to permit filtration to take place at different pressures. Pressure is created by moving the reservoir of water to a different height relative to the tested specimen. Water was passed through a specimen according to the "bottom-to-top" flow pattern, after which it was collected in a graduated cylinder. Lest the water evaporate from the graduated cylinder, several drops of oil were dropped into it. All experiments were performed at pressures of 0.32 meter, 0.60 meter and 0.80 meter. Filtration rate and coefficient were determined several times for each one of the given pressures [2]. Water temperature was measured constantly during the experiments and all results have been referred to a temperature of  $+10^{\circ}$  C. Experiments were conducted at various vertical loads with a wait at each loading step for subsidence to stabilize at  $0.01 \cdot 10^{-3}$  meter in 12 hours. Graphs were constructed for every value of vertical load according to the obtained data for variation of filtration rate as a function of pressure gradient. Extensions of

the straight lines joining individual experimental points to their intersection with the axis of pressure gradients mark off on it the initial gradient value at which filtration begins (Figure 2). The initial pressure gradient obtained according to the thus-described methodology was checked by filtering water through the same soil sample at a gradient less than the initial gradient. From the graphs in Figure 2 it can be seen that for sandy mud the initial gradient increases as the vertical load increases. For clayey mud the initial gradient remains practically unchanged with an increase of the vertical load in the tested range due to low compressibility (the porosity factor varied from 2.44 to 2.25). For buried peat the same pattern as for sandy mud was observed, i.e., the initial pressure gradient increases with an increase of the vertical load. Given  $p = 1.0 \cdot 10^5 \text{ N/m}^2$  it equals 1.2, while given  $p = 2.0 \cdot 10^5 \text{ N/m}^2$  it increases to 3.2.

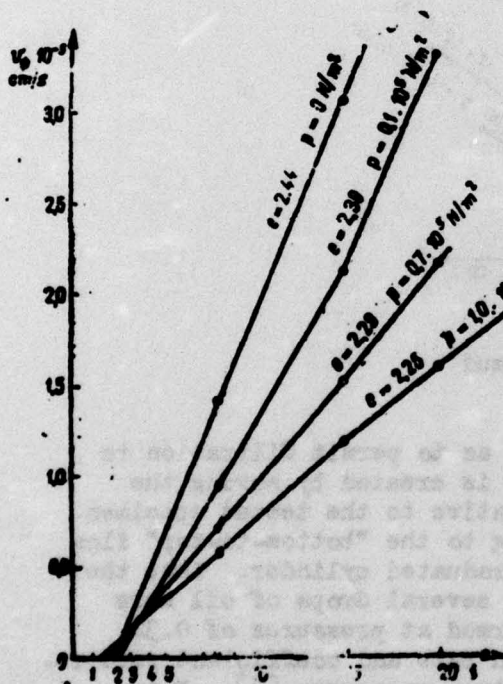


Figure 2b. Clayey mud

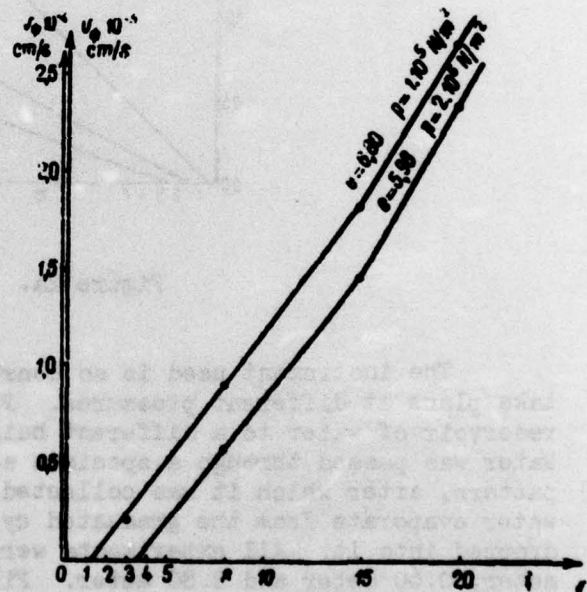


Figure 2c. Buried peat



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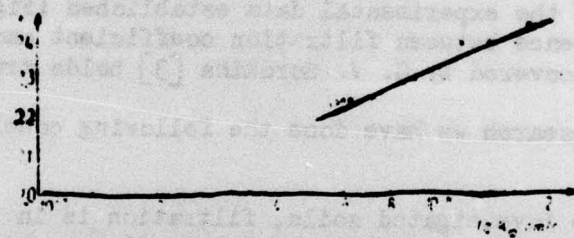
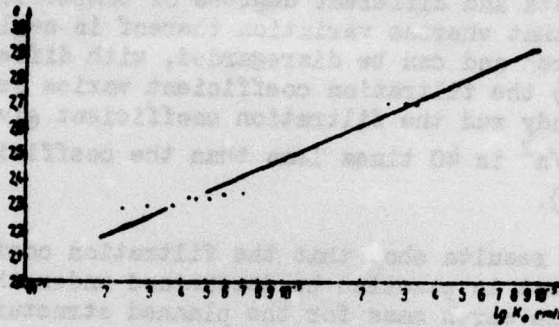


Figure 3a, b. Sandy mud; clayey mud.

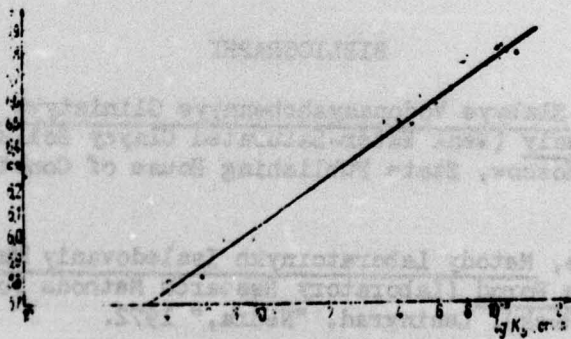


Figure 3c. Buried peat



The second task we set ourselves in the experiments here conducted was to investigate the variation of the filtration coefficient at different pressure gradients and different degrees of compaction (vertical loads). The results showed that whereas variation thereof is negligible for the investigated pressures and can be disregarded, with different degrees of compaction (loading) the filtration coefficient varies several fold. Thus, for example, for sandy mud the filtration coefficient given vertical load  $p = 1.1 \cdot 10^5 \text{ N/m}^2$  is 40 times less than the coefficient given  $p = 0.1 \cdot 10^5 \text{ N/m}^2$  (Figure 3a).

The obtained results show that the filtration coefficient for these varieties of soil must in practice be determined under the same vertical loads under which the earth mass for the planned structure will find itself.

Analysis of the experimental data established (Figure 3) that the logarithmic dependence between filtration coefficient and porosity factor in muddy soils discovered by G. V. Sorokina [3] holds true.

From the research we have done the following conclusions can be drawn:

1. For the investigated soils, filtration is in practice observed only at gradients greater than the initial gradient, which increases as the porosity factor declines, i.e., as the vertical load increases.
2. For the investigated soil varieties there is a logarithmic dependence between the filtration coefficient and porosity factor.
3. Filtration research for weak water-saturated soils must be conducted under the vertical loads that will be observed at the planned structure.

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